SUMMARY OF THE TRACKING SESSIONS

Snowmass ALCPG ILC meeting

P. Colas (DAPNIA/Saclay)

General thoughts

Simulation

Alignment

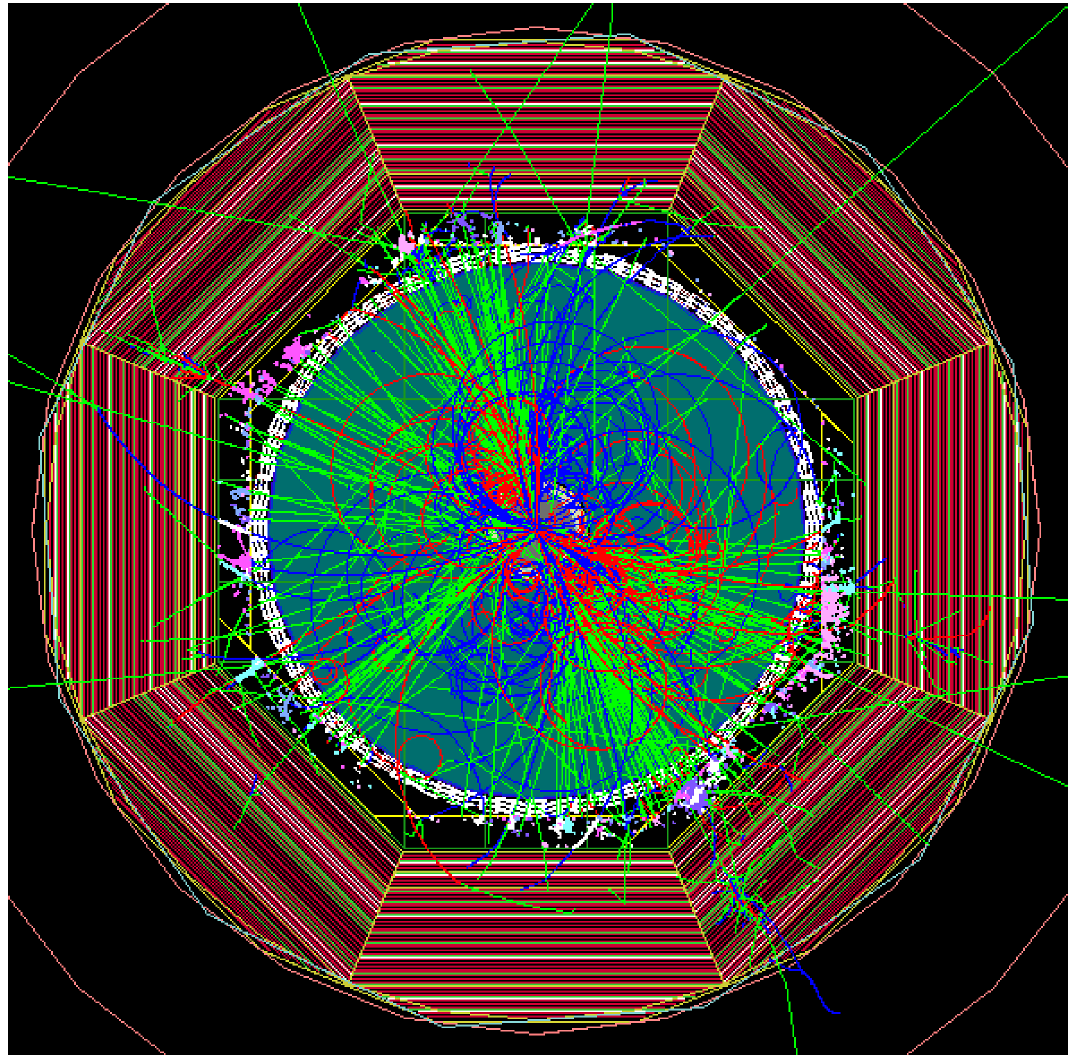
Test beams

Si tracker R&D

TPC R&D

InGrid

What's left?



A Mokka simulation of tt to 6j in LDC (courtesy of V. Saveliev) simulation

- **Role of the tracking**:
  - PFLOW
  - Precision momentum measurement

Forward region
is important
for physics

Positionning

FSI

R&D,
Technology

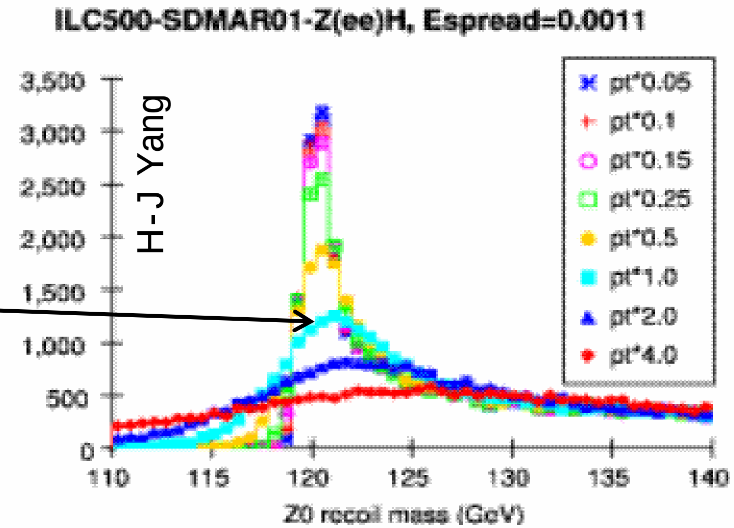
tests

General thoughts

(Ron Settles and Bruce Schumm)

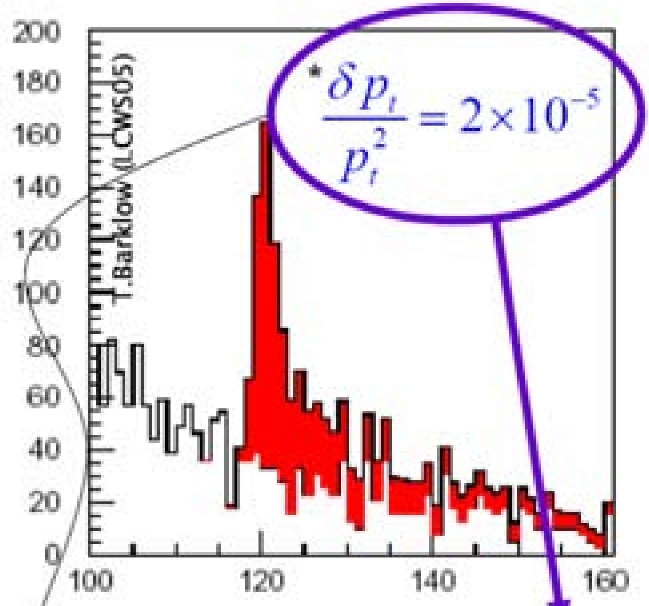
e+e- -> HZ -> anything μ+μ-

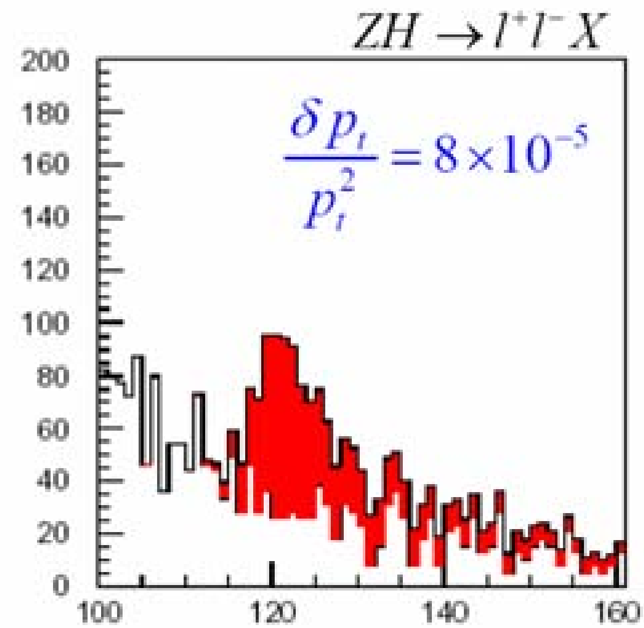
Recoil mass spectrum allows M_H acurate measurement however it decays



$\delta pt/pt^2$=2. 10^{-5} GeV^{-1}

But the H peak is washed out if we fail to obtain the nominal resolution 5.10^{-5}

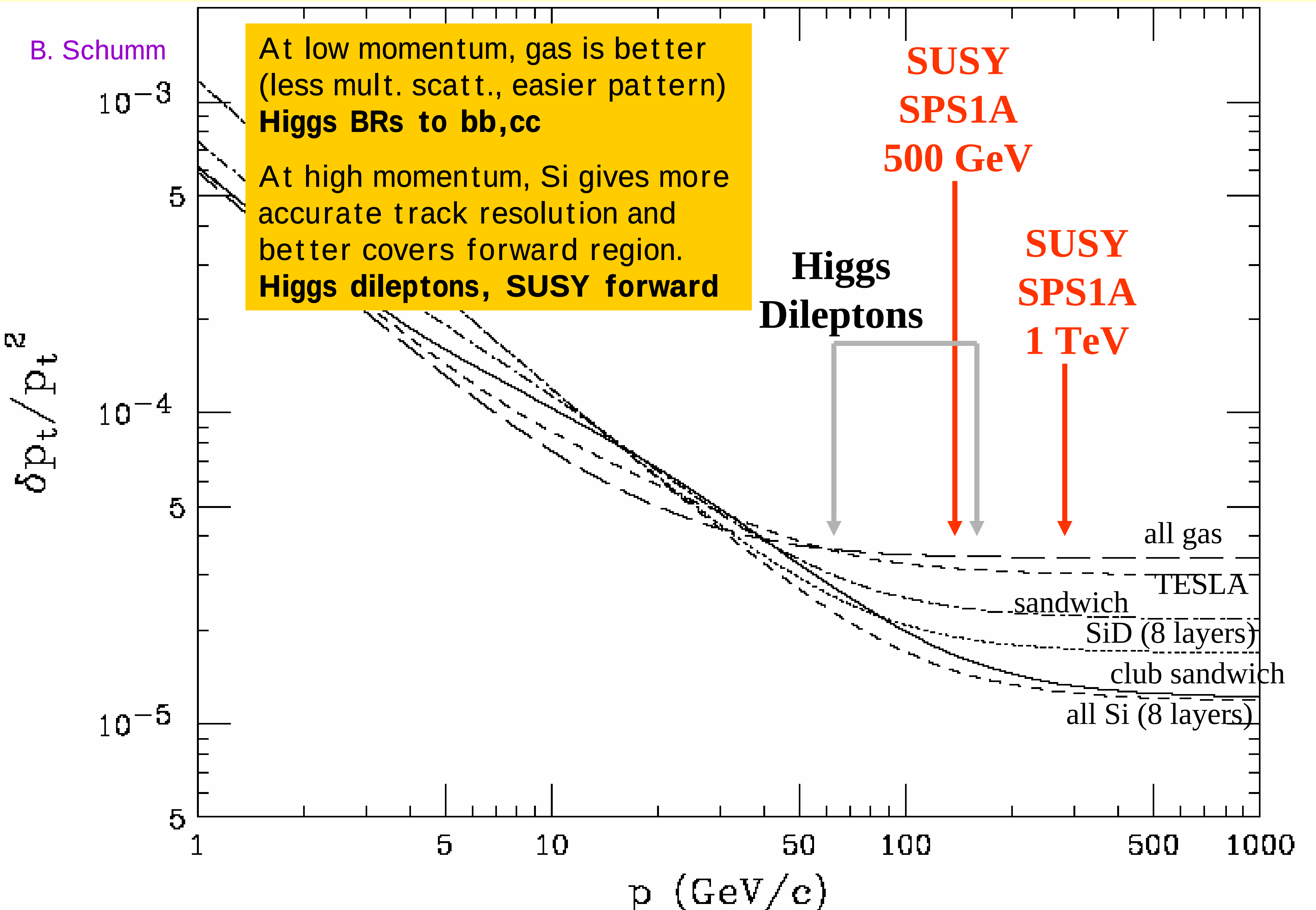




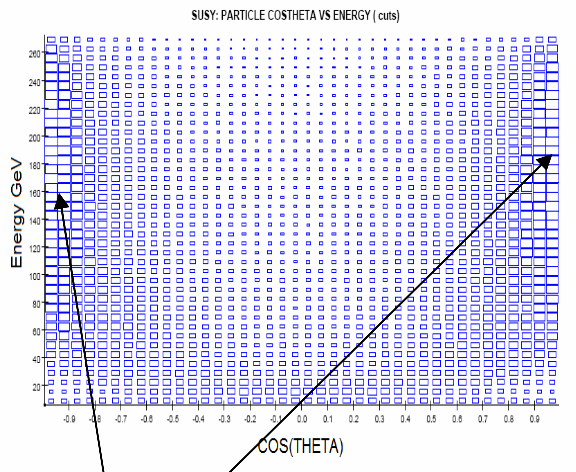
10 μm sagita over 1.2m

20 x better than LEP

Z recoil mass


B. Schumm
At low momentum, gas is better
(less mult. scatt., easier pattern)
Higgs BRs to bb,cc
At high momentum, Si gives more
accurate track resolution and
better covers forward region.
Higgs dileptons, SUSY forward
SUSY
SPS1A
500 GeV
Higgs
Dileptons
SUSY
SPS1A
1 TeV
all gas
TESLA
sandwich
SiD (8 layers)
club sandwich
all Si (8 layers)
10^{-3}
5
10^{-4}
5
10^{-5}
5
1
5
10
50
100
500
1000
$\delta p_t / p_t^2$
p (GeV/c)

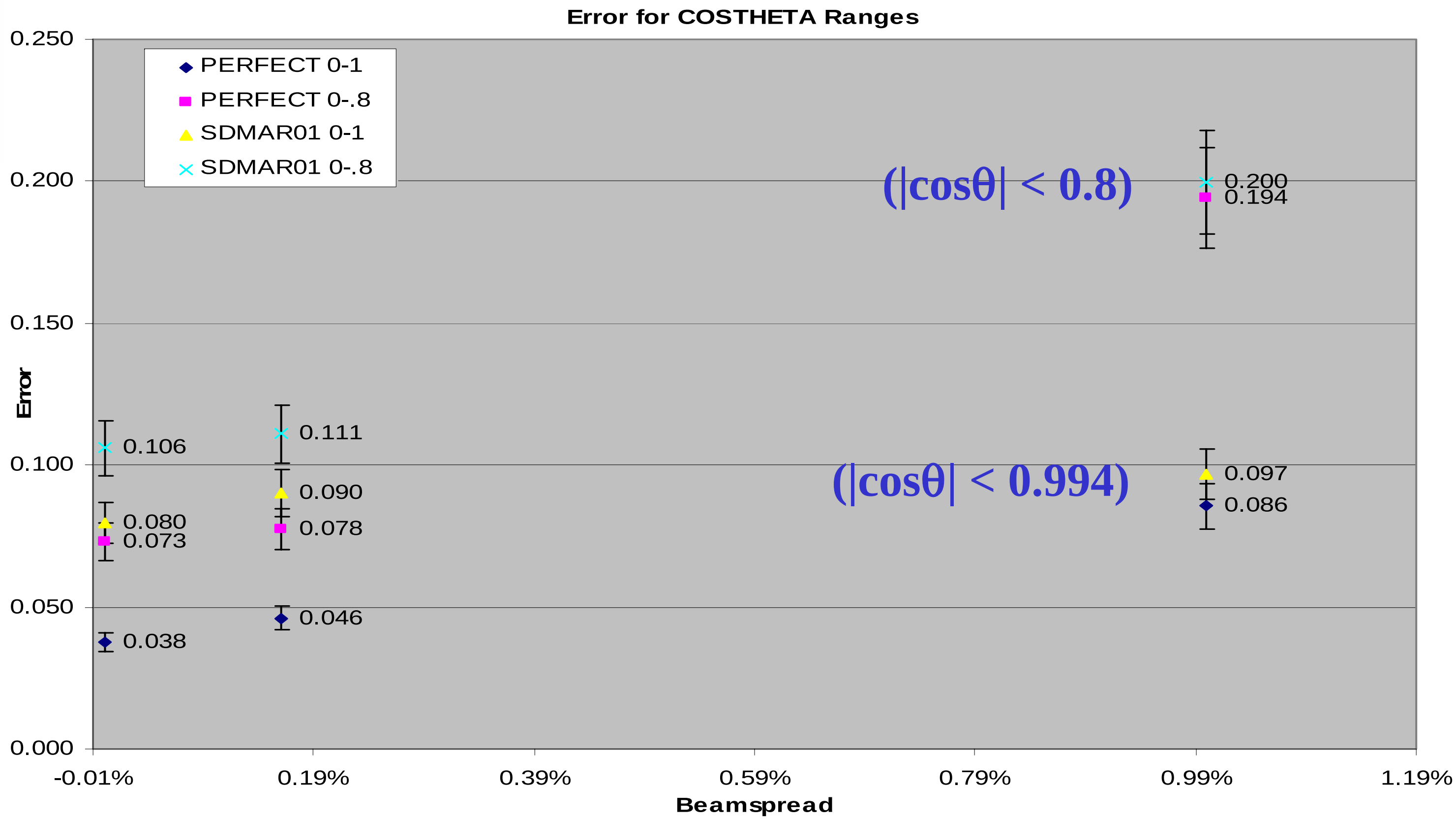
Selectron production



High energies are forward

Needs excellent point resolution in forward direction

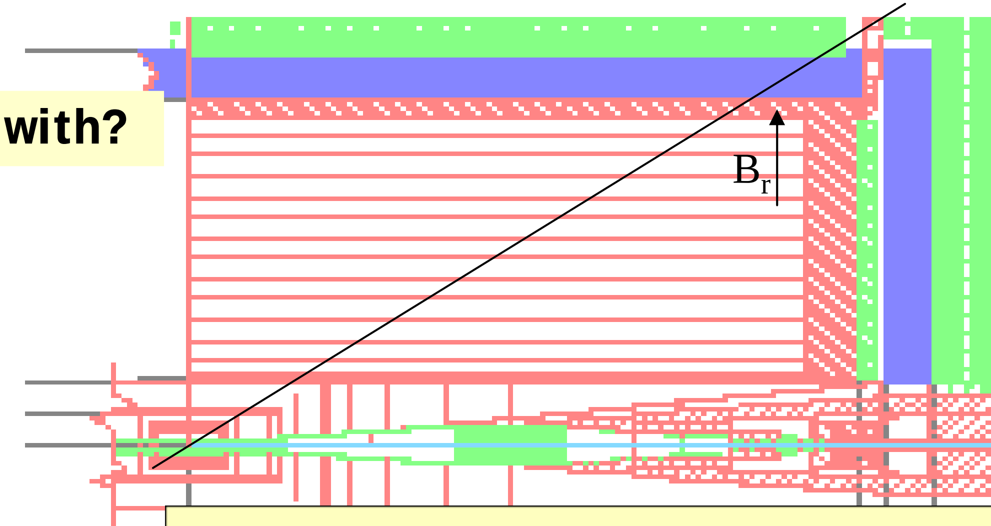
Error on m(selectron) (GeV)



Using the forward direction buys you x2 statistics and better accuracy on the endpoint, even at large beam spread (B. Schumm, Troy Lau)

Magnetic field homogeneities

(Dan Peterson, Ron Settles)



What level of inhomogeneity can we live with?

D.P. has looked at two kinds of distortions

B_r increasing linearly with R and z : changes the cord

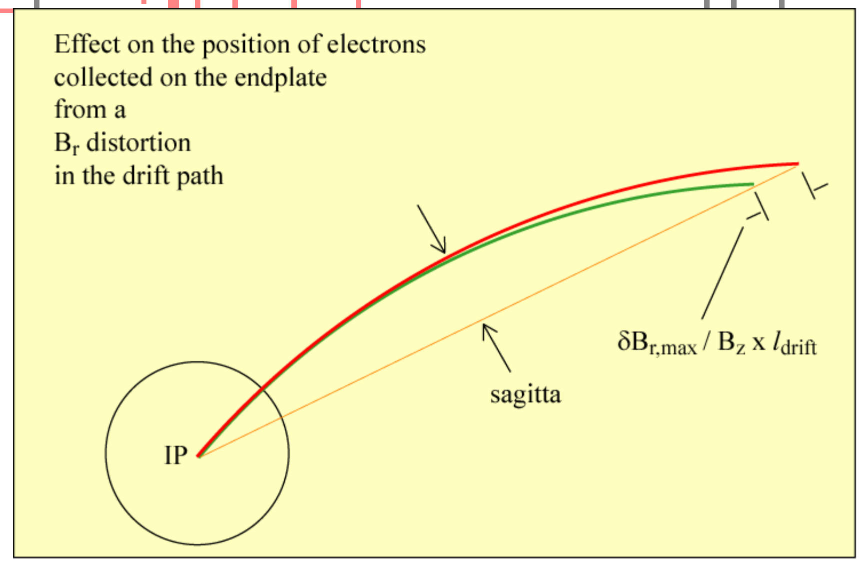
$B\phi$ increasing linearly up to mid radius : changes the sagitta

If we want these effects to be <5% of the track error, we need residual uncertainties :

systematic B_ϕ, $\delta B/B_z < 2 \times 10^{-5}$

systematic B_r, $\delta B/B_z < 7 \times 10^{-5}$

(Result of a both-sides-of-a-large-envelope calculation)

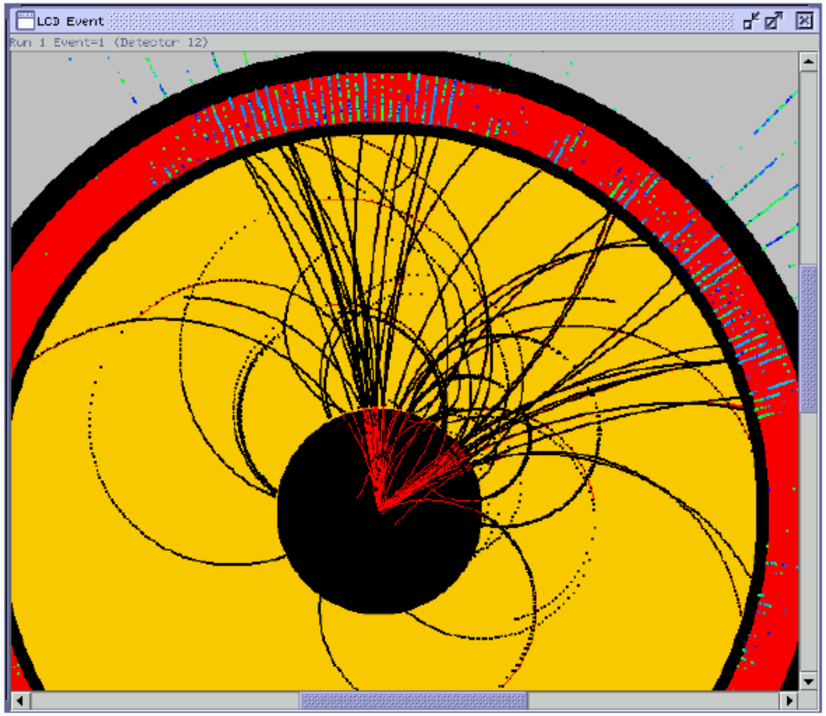


To be safe, the field should be known at the level of 1×10^{-5}

(ALEPH achieved $3.5\ 10^{-5}$)

Problem to be studied very seriously

Simulation and reconstruction



Java program associating all hits triplets to build tracks out->in (M. Ronan)

Two kinds of simulation programs

details of signal build-up, propagation in matter, avalanche in gases, etc... (see in R&D section)

track/hit simulation for concept studies, benchmarking

Tracking: from outside in ? Or from inside out?
VXD based, in->out, based on BaBar (N. Sinev)

Track cheater: keep track of the hits, to make more realistic simulation of reconstruction errors than simple smearing. For instance, remove shared hits and cut on min number of hits.(M. Ronan)
SGV (simulation a grande vitesse, M. Bergren) is used for forward chamber simulation. (L.Sawyers) -> matter is critical

Mokka now includes tracking simulation for the 3 detector concepts (V. Saveliev)

New release of detailed TPC simulation, LCIO based (M. Killenberg)

http://www.physik.rwth-aachen.de/ group/IIIphys/TPC/en/software/

Effort towards standards has to be sustained, to facilitate comparisons

Test beam facilities

(session co-chaired by Jae Yu and Bruce Schumm)

Features:

Energy : 1 to 120 GeV

Particles : e, p, K, p, mixed or pure (Cerenkov)

Intensity

Time structure (spill length, repetition rate)

Safety rules, accessibility, availability

SLAC very stringent safety rules. Down to 1 e/spill, t(spill) < 1 ps to 3 ps

Fermilab **MTBF** (meson test beam facility) 4 secondes every 2 minutes)

Fermilab **MCBF** (main injector, meson center)

CERN : all particles and energies, but limited availability

DESY : 6 GeV electrons

KEK : hadrons 1-12 GeV, closed end of 2005

Bonn : SiLC+DEPFET

We should have more input on future beam designs and operation

(EUDET++...)

Test beam facilities

Initiative to improve test beam infrastructures for the ILC detector(s)

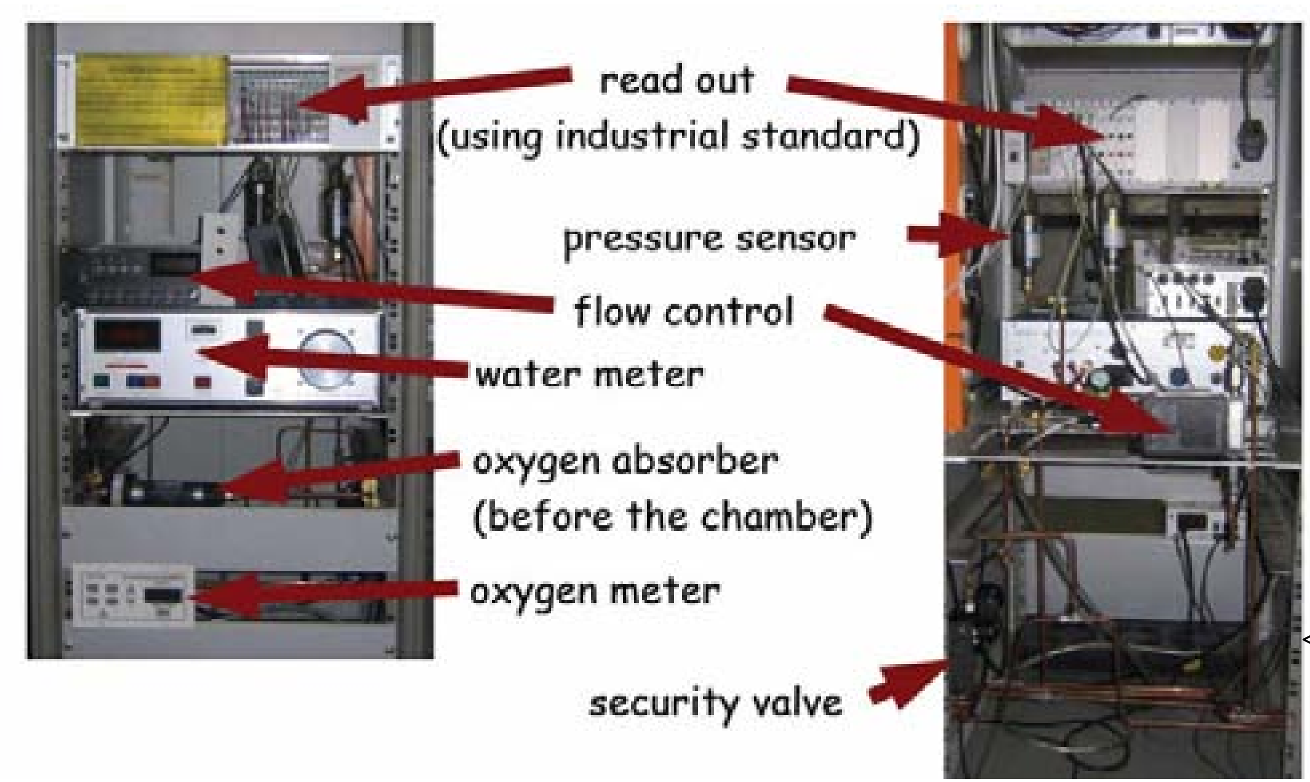
55% for tracking and vertexing

Electronics, slow control, telescopes, TPC field cage, magnet (from Japan) and part of the R&D.

7 M€ of funding by EU

Open to all countries, transportable.

(J. Mnich, Coordinator)



Low cost slow control for the DESY TPC

T. Behnke, DESY Hamburg

Alignment: Frequency Scanned Interferometry

(Hai-Jun Yang, S. Nyberg, K. Riles)

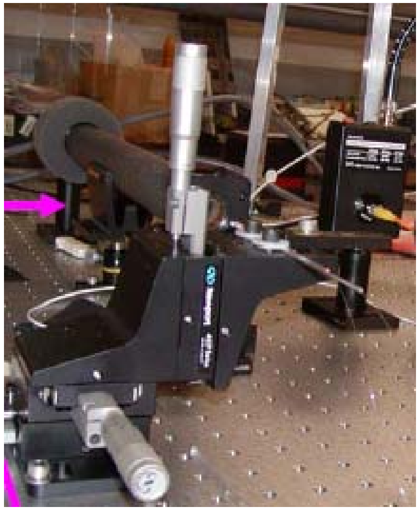
U. Michigan, Ann Arbor

Alignment system: measure position, pitch, roll, yaw, distortions, vibrations of Si ladders, TPC sectors, VTX cryostat, etc…

Method: vary laser frequency and count fringes in a Fabry-Perot interferometer

Absolute distance measurements : single measurements ~1μm, multiple measurements 20 to 50 nm over 10 to 60 cm

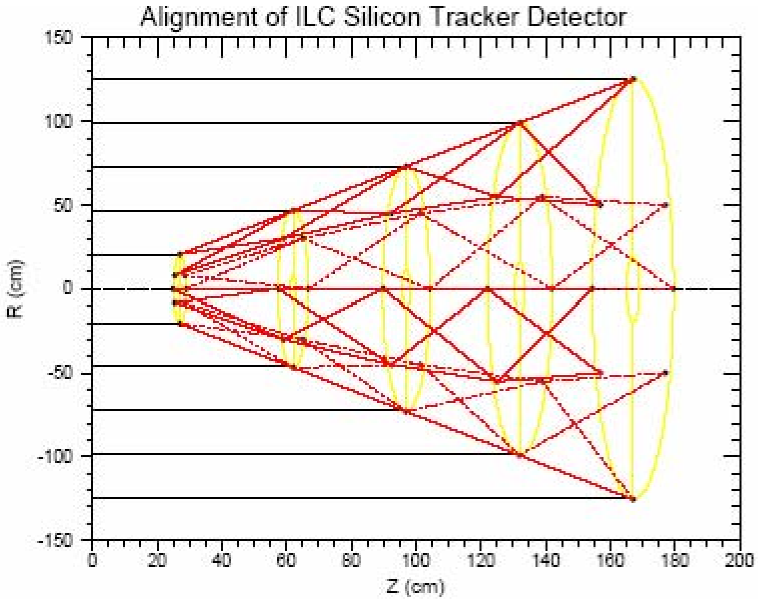
Vib. Measurements : amplit. few nm to μm

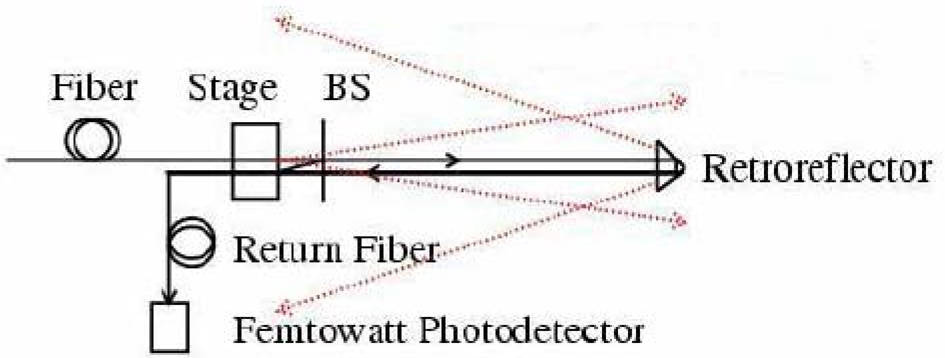


Evolution from ATLAS SCT.

Also available: RASNIK coded mask technology from NIKHEF

CMS and ATLAS μ-chambers





752 point-to-point distance measurements

GEM and Micromegas : a tutorial for theoreticians

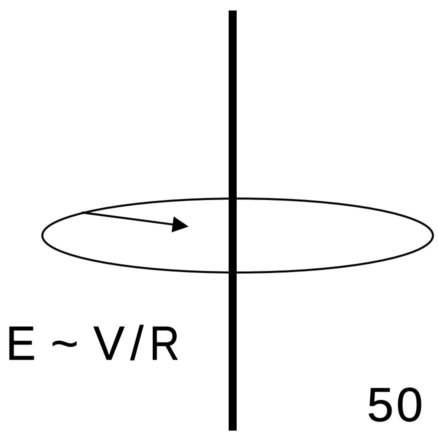
In a gas, with low electric fields, electrons kinetic energies are limited to O(0.6 eV) due to collisions.

At high enough fields (20 kV/cm) electrons are accelerated to O(10-20 eV) between two collisions : enough to ionise. 1 e- ⇨ 2 e-

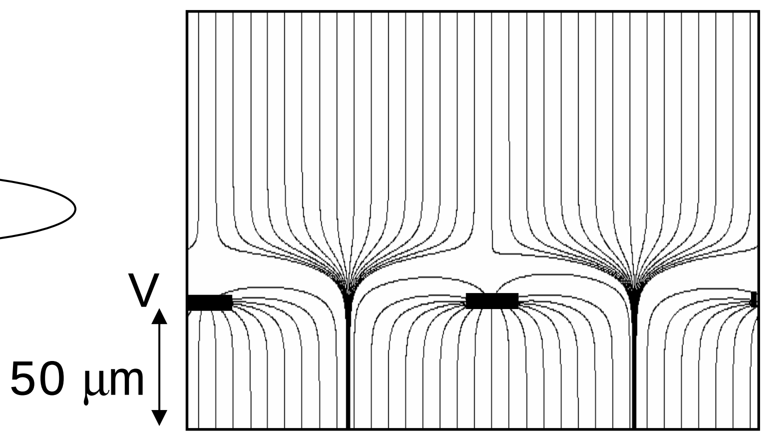
Doing that 10 times (takes 50 to 100 µm), you get 2^{10} = 1000 e-, (avalanche) enough to be detected by a low-noise charge amplifier.

3 ways of making high fields:

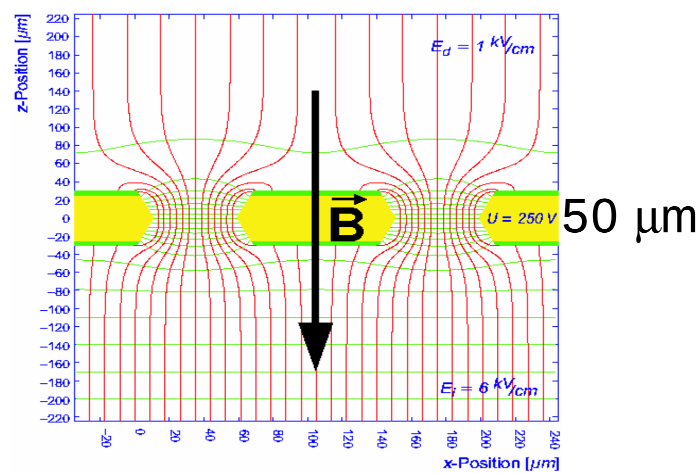
10 µm wire



Micromegas

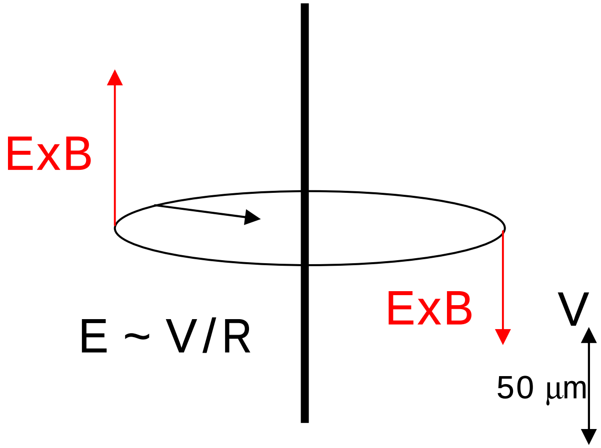


GEM



GEM vs Micromegas : a difficult choice

10 μm wire



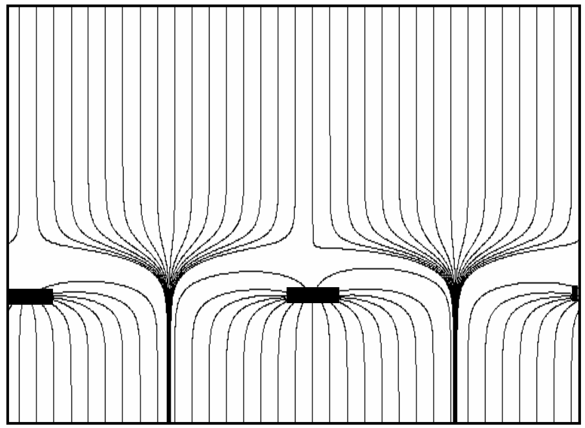
ExB dislocates clusters

Long charge collection (1/t)

Wires break sometimes

Need strong frames

Micromegas

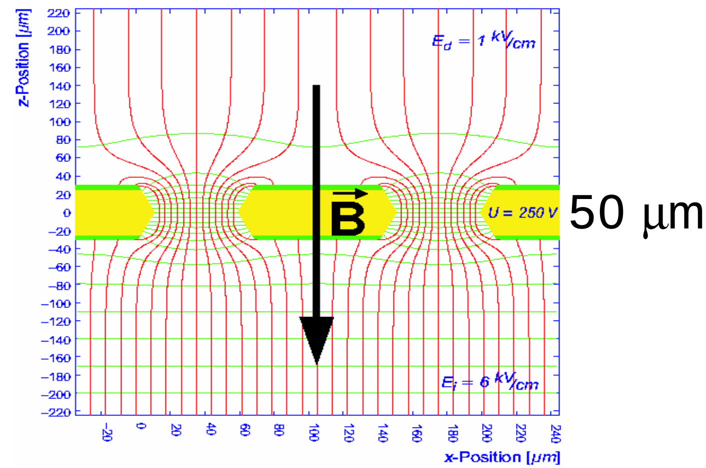


Fast and efficient charge collection (100ns)

Techniques exist to avoid frames

1 stage: simple but close to the sparking limit

GEM



Fast charge collection

2-3 stages: more stable but more complicated (and destructive sparks?)

Natural defocusing helps barycenter defocusing

Much R&D ongoing, world large prototype should settle

TPC R&D

Drift properties of the gases. Gas choice might depend on technology. Understand point resolution, double-track resolution, behaviour in magnetic fields, positive ion backflow

Many R&D efforts

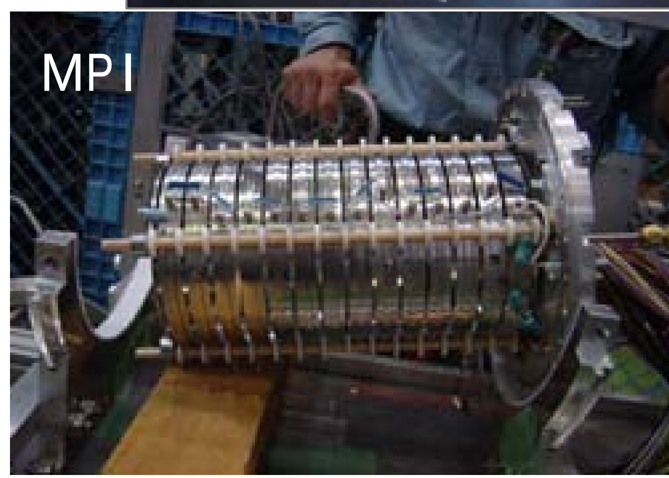
DESY/U. Hamburg +U. Rostock	T. Behnke (~10 persons)	GEM
Aachen	M. Killenberg (6)	GEM
Victoria	D. Karlen, P. Poffenberger, Gabe Rosenbaum	GEM
Asia+MPI	A. Sugiyama (25 participants)	GEM, W
Asia+MPI+ Orsay-Saclay + Carleton	P. Colas (30 participants)	mM
Carleton-Montréal	M. Dixit (10)	GEM, mM
Cornell-Purdue	Dan Peterson (6)	GEM, W
Berkeley-Orsay-Saclay		mM

~ 70 active researchers

TPC R&D

...and many interconnections

Karlsruhe,
Berkeley,
Novosibirsk,
Asia,
Carleton,
Cornell



MPI TPC beam tests at KEK

(A. Sugiyama, P. Colas)

Motivation (Ron Settles)

Unbiased comparison of several sensors using same Field Cage, Electronics, Analysis,, based on MPI-TPC

MWPC (original) : Beam test @ Jun. '04

GEM : Beam test @Apr.'05 (This talk)

MicroMEGAS : Beam test @Jun.'05 (Paul's talk)
w/ Saclay, Orsay, Carleton
w/ Resistive foil : Beam test is scheduled @Oct.'05
w/ Saclay, Orsay, Carleton

Complete understanding of MPGD TPC

We have to accumulate enough knowledge to design "real TPC".

Asia + MPI, DESY

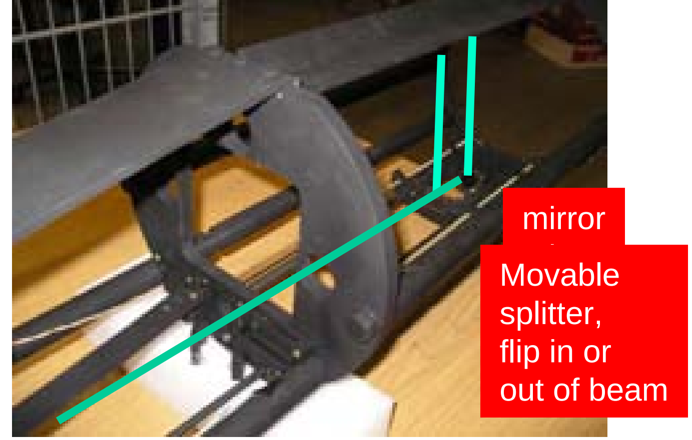
KEK
U. Tsukuba
Kogakuin U.
TUAT
U. Tokyo
Kinki U.
Hiroshima U.
Saga U.
Mindanao SU
(from North to South)

+Orsay, Saclay, Carleton

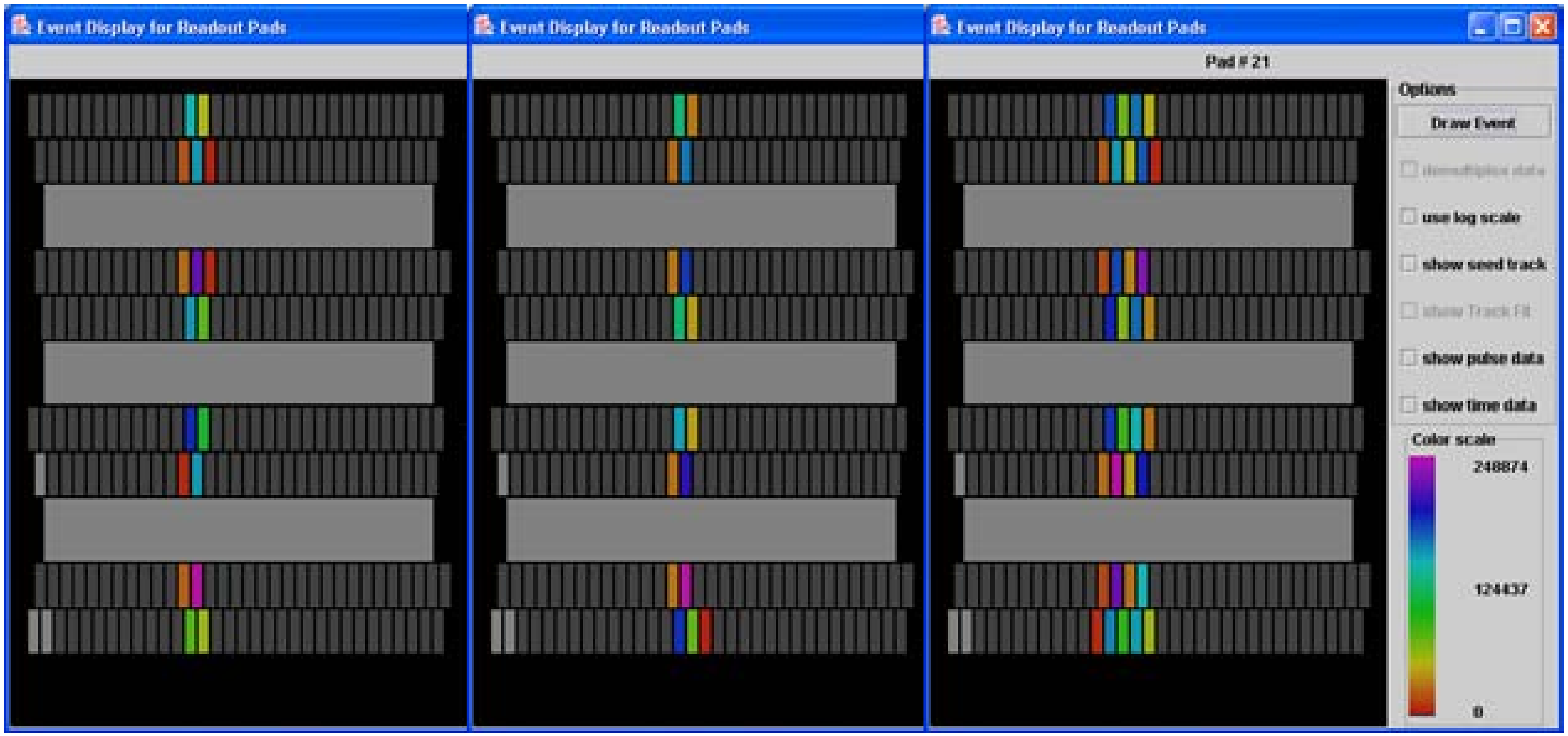
TPC R&D – Two-track separation

Victoria TPC at DESY, Victoria laser beam

Track resolution degraded by 10% at 4mm, by 40% at 1mm, with 2mm pads (D. Karlen)

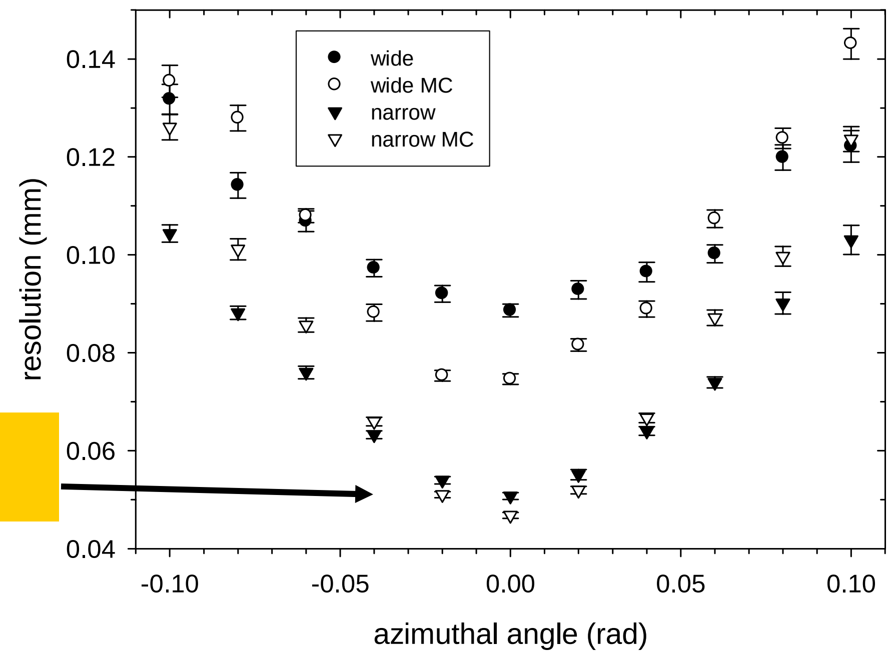


Beam 1 only   Beam 2 only   Beam 1 and 2



TPC R&D – Track-angle effect

Point resolution deteriorates with angle between the pads and the track, as expected. Cosmics, data and MC (D. Karlen)



50 μm with 1mm pads

Gas properties

Very accurate measurement of drift velocity and diffusion coefficients (KEK testbeam, June 2005) (P. Colas)

V_{drift} (Ar+5%iso) = 4.181 +- 0.034 cm/μs

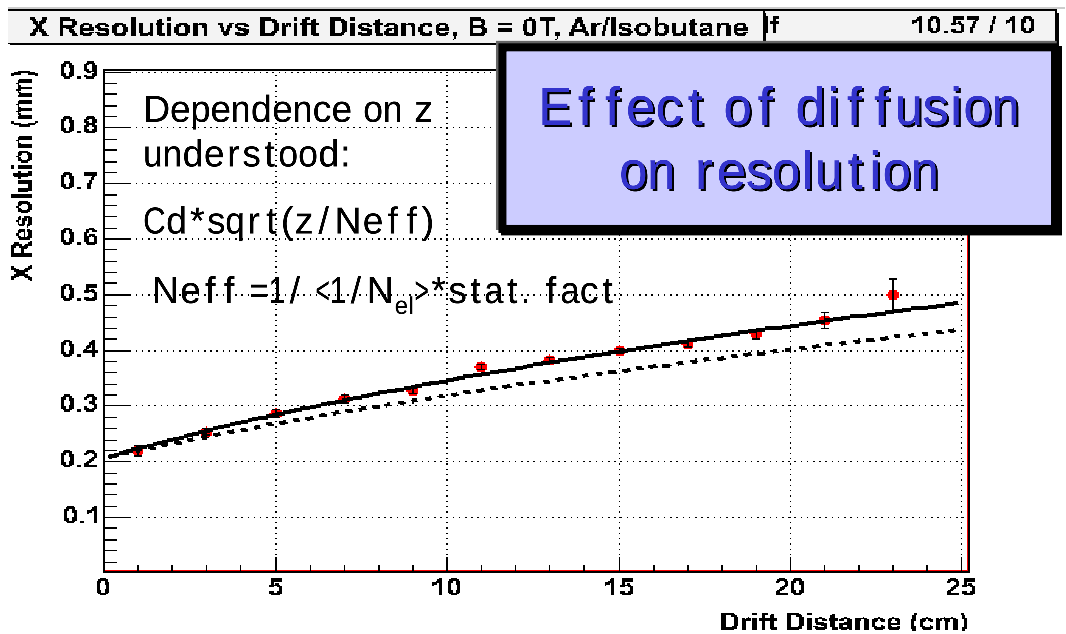
Magboltz simul. : 4.173 +- 0.016

B=0 T $\quad C_D = 480. \pm 4.[\mu m] = 469(\mathrm{Magboltz})$

B=0.5 T $\quad C_D = 293. \pm 4.[\mu m] = 285(\mathrm{Magboltz})$

B=1 T $\quad C_D = 188. \pm 17.[\mu m] = 193(\mathrm{Magboltz})$

Effect of diffusion on resolution

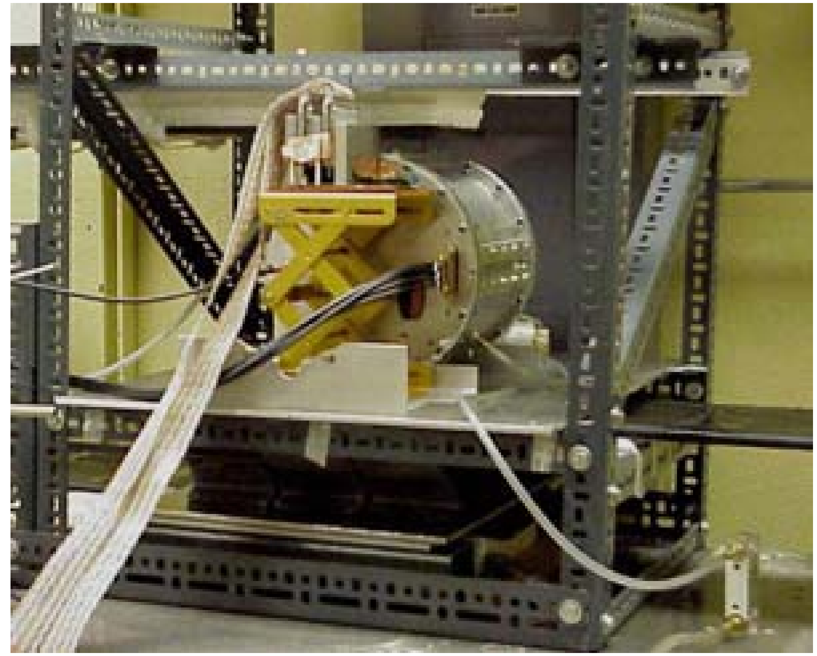


Dependence on z understood:

Cd*sqrt(z/Neff)

Neff =1/ <1/N$_{el}$>*stat. fact

TPC R&D – Spreading the charge

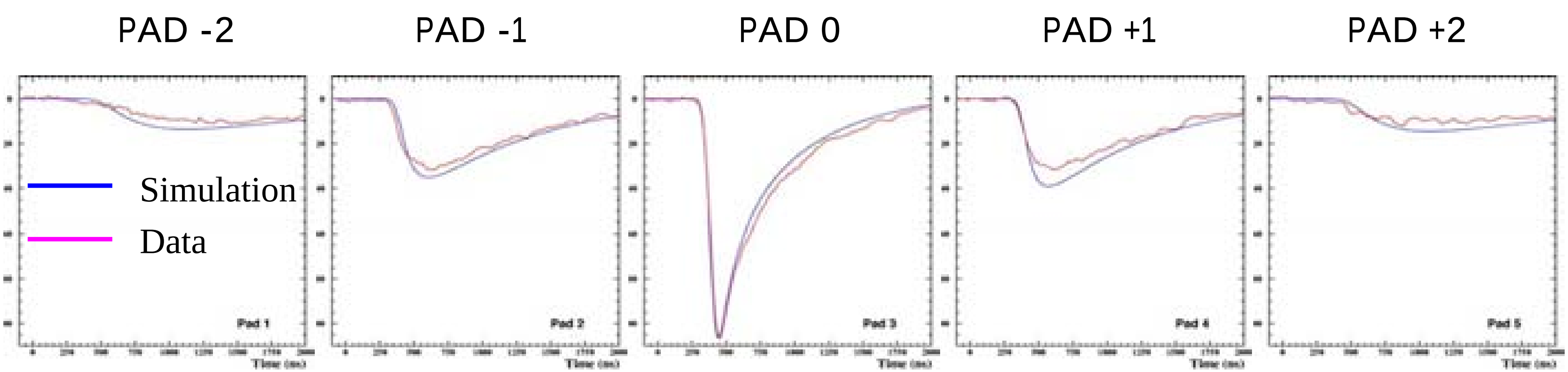


Excellent resolutions are measured, but we expect that at 4T, with 2mm pads, the clusters are contained in a single pad, giving a point resolution of 2mm / sqrt(12) = 580 μm !!

It is necessary to spread the charge to make a barycenter.

At Carleton, a resistive foil is used for this

(M. Dixit)



TPC R&D – Spreading the charge

Resolutions less than 70 microns are observed both for GEM and Micromegas.

The diffusion limit is reached for the dependence on the drift distance

With 2mm pads, at 2 m drift, a resolution of 100 μm is feasible.

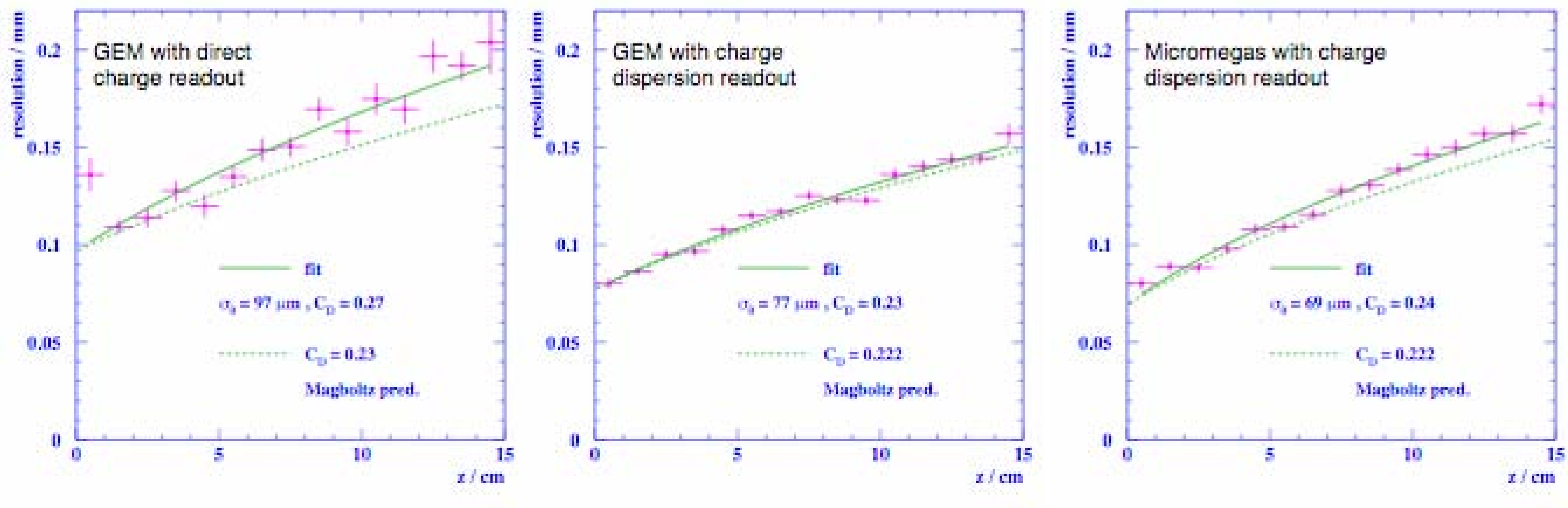
(M. Dixit)

Next step: tests in the Jacee magnet at KEK (October 2005)

R.K.Carnegie et.al., NIM A538 (2005) 372

R.K.Carnegie et.al., to be published

New results



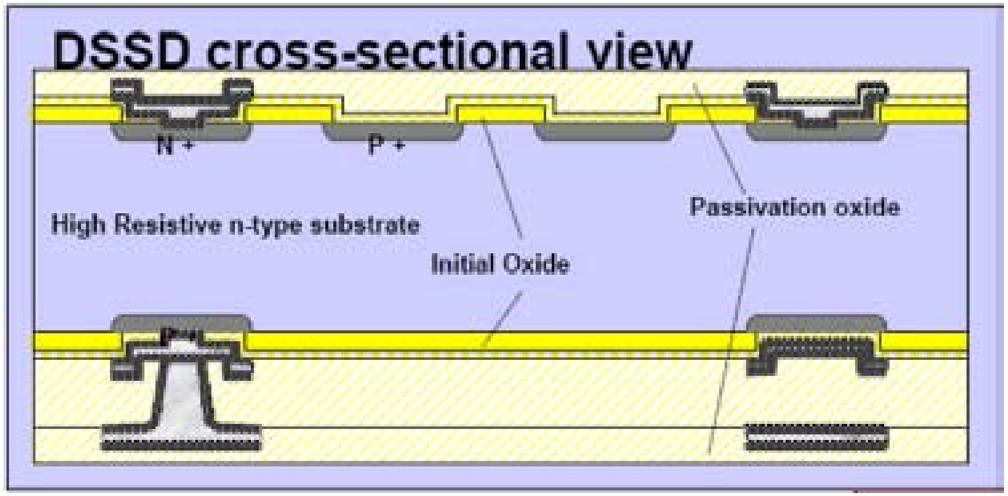
Silicon R&D

Double sided Si Detector R&D at U. Korea. Intermediate tracker in GLD (E. Won)

Rad. hardness test in progress

S/N measured to be 25

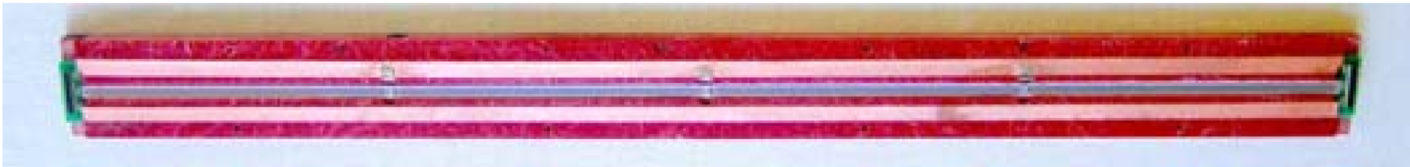
First hybrid card just produced.



Long ladders in Santa Cruz (B. Schumm) LSTFE chips : new design in 0.25 μm technology, to accomodate long and spaced trains (cold RF technology) submitted after LCWS05, received Aug. 11. Gain follows expectation.

Backend architecture defined

Long laders being assembled

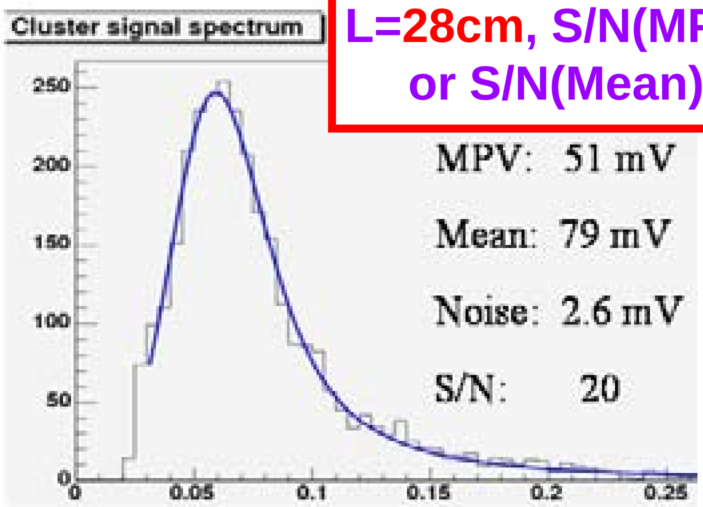


Silicon R&D – Medium size ladders, new design and tests

(A. Savoy-Navarro, SILC collaboration)

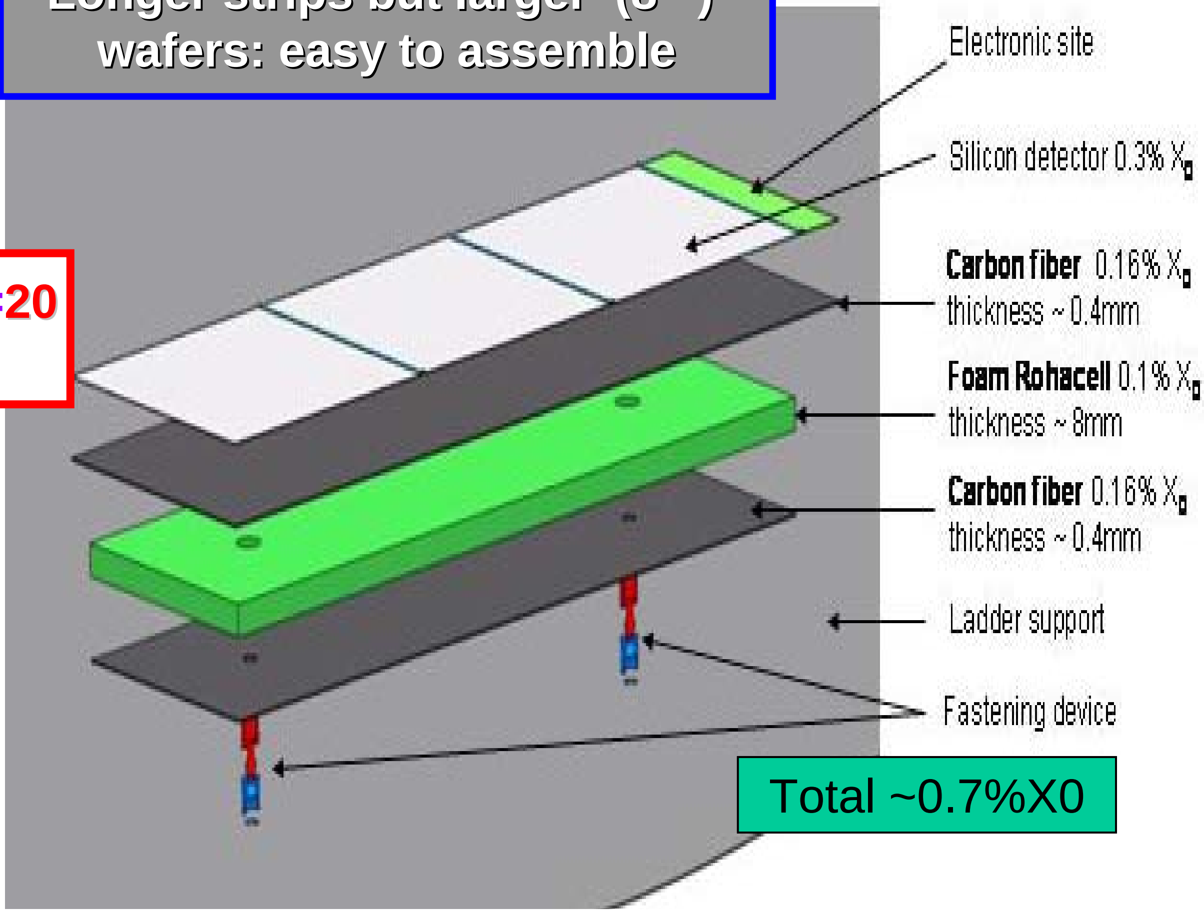
10 to 60 cm strip length

Depending on detector location



L=28cm, S/N(MPV)=20
or S/N(Mean)=30

Longer strips but larger (8 ”) wafers: easy to assemble



Total ~0.7%X0

[90]Sr source tests show Signal/Noise satisfactory, to be pursued in a beam test in Bonn end 2005 and with the new front-end readout chip.

First prototype by October

Silicon R&D – Front-end readout in 180 nm CMOS technology

(J.-F. Genat, SILC collaboration)

Received Feb 2005. On-going thorough tests of 20 chips (16 channel ea.)

Very encouraging results :

498 + 16.5 e-/pF measured

490 + 16.5 e-/pF expected

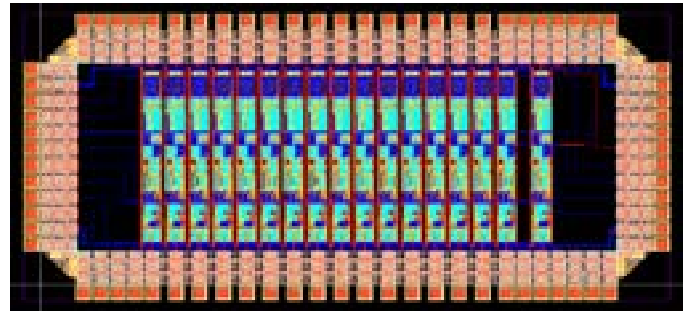
Process spread 3.3% on the preamp gain

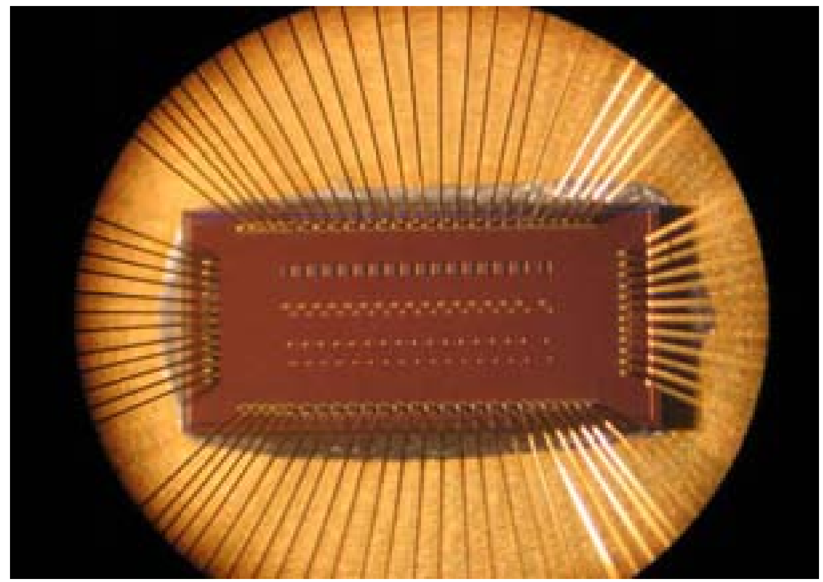
Proven to be a mature technology

Next version under layout (128 ch.)

Power cycling under development

Layout and Silicon



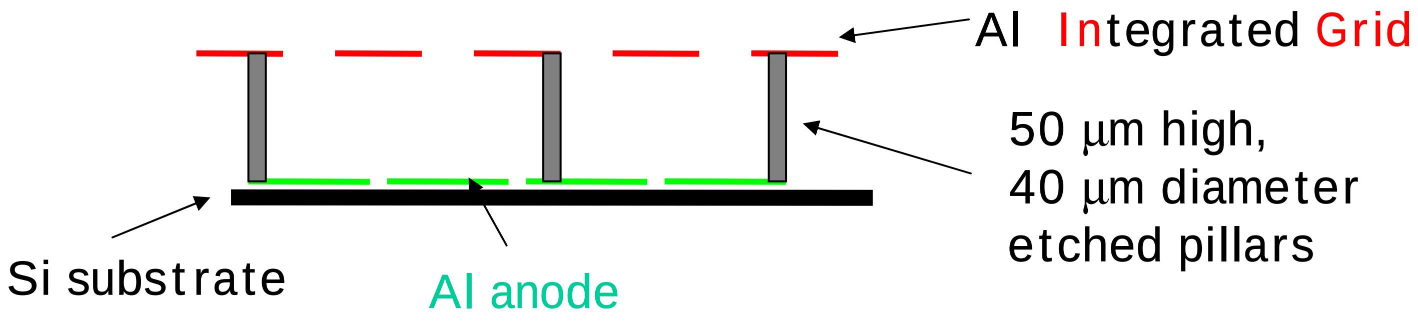


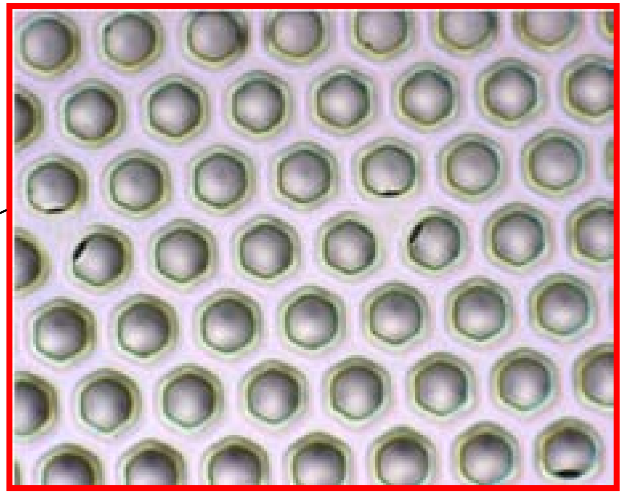
3mm

InGrid, an integrated Micromegas made in Silicon wafer post-processing technology

(M. Chefdeville , P. Colas,
H. van der Graaf, J. Timmermans et al.)

NIKHEF-Saclay CERN Twente Collaboration

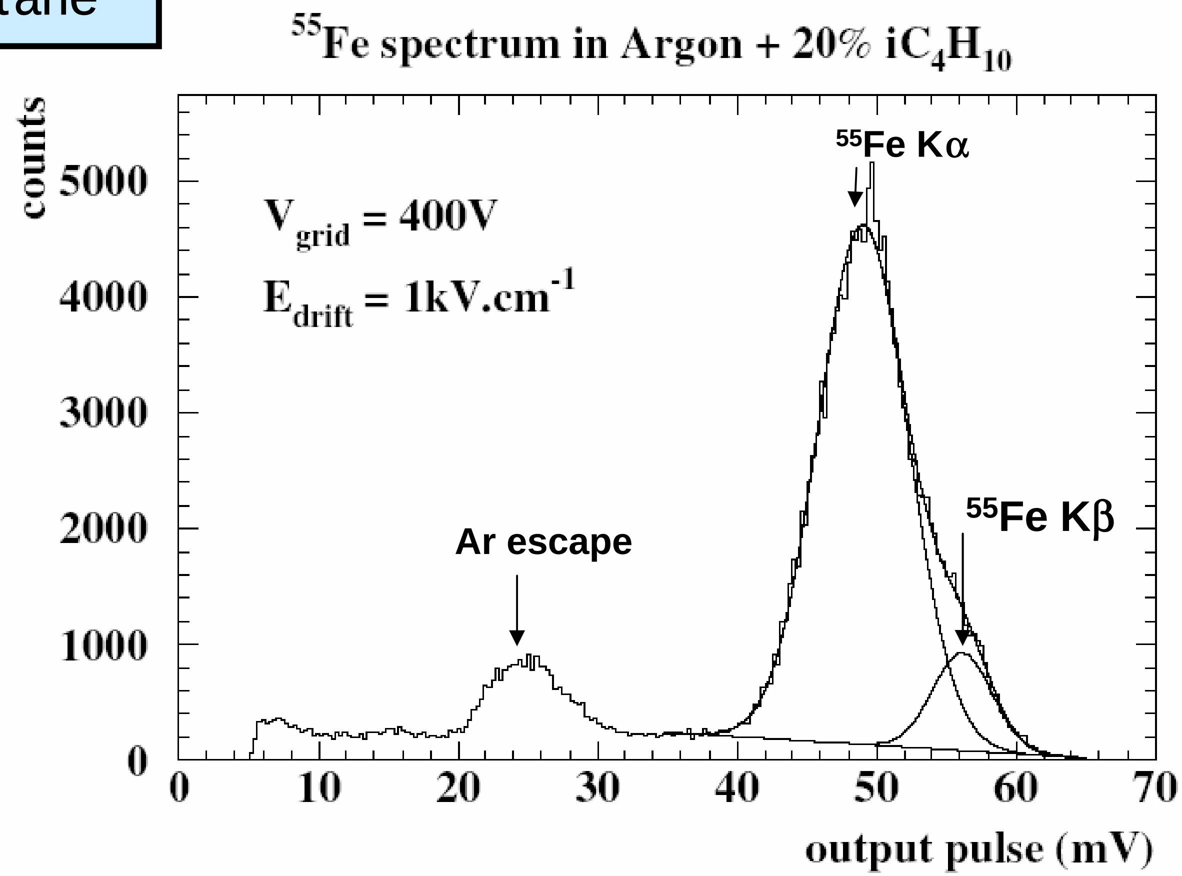




Results in Argon + 20% isobutane

Advantages

- grid thinness & robustness
- gap accuracy (unprecedented resolution (6.5%) and uniformity)
- no frame (no loss of active surface)
- possibility to fragment the mesh (noise reduction and extra-localization usable for zero-suppression)



Future : Si TPC (with the Timepix VLSI CMOS readout) 55 μm pads

EUDET-funded

Conclusion

Many new ideas have been demonstrated, at least in principle.

R&D is becoming truly international.

The design of a Large Worldwide TPC prototype starts now, to take data early 2008.

Still many challenges ahead of us :

Magnetic field inhomogeneities

Mechanical accuracy, actual implementation, power dissipation

These could affect the choice of technology and even the conceptual choices.